

Rejections Under 35 U.S.C. 112

The Office Action rejects dependent claim 16 as lacking enablement for its recitation of depositing at least one of the metallic layers on a surface of the active region by employing molecular beam epitaxy. In particular, the Office action asserts that “the specification discloses the formation of the active region via MBE, and the metal layers being “deposited” thereafter without disclosing the deposition method.”

In response, claim 16 is amended to recite that the method of claim 15 further comprises forming the active region by molecular beam epitaxy. Support for this amended can be found, e.g., on page 8, paragraph 34.

The Office Action rejects dependent claim 17 because “the specification discloses the deposition of metal layers, followed by a wafer bonding technique,” and that “[T]his does not correspond to the claim language stating the metal layers are “generated” using wafer bonding.”

In response, Applicants note that the specification recites that “[A] low temperature wafer bonding technique, described in detail below, can be *employed to generate* the double-sided metal waveguide.” [Emphasis Added] page 8, paragraph 34. In other words, the language of claim 17 tracks precisely that of the specification.

Accordingly, withdrawal of the above 112 rejections are respectfully requested.

Rejections Under 35 U.S.C. 103(a)

The Office Action rejects claims 1-6, and 8 as being obvious over an article authored by Unterrainer *et al.* entitled “Quantum cascade lasers with double metal semiconductor waveguide resonators,” in view of an article authored by Xu *et al.* entitled “Electrically pumped tunable terahertz emitter based on intersubband transition.”

Claim 1 recites a quantum cascade laser that comprises an active region for generating lasing radiation in a frequency range of *about 1 to about 10 Terahertz*, and

a waveguide formed of an upper metallic layer and a lower metallic layer. Each metallic layer is disposed on a surface of the active region so as to confine selected modes of the lasing radiation within that active region.

Unterrainer discloses quantum cascade lasers that operate in shorter wavelengths of 19, 21 and 24 microns. The considerations for mode confinement in quantum cascade lasers operating at these wavelengths are not necessarily applicable to those that operate in the claimed frequency range, especially at the lower end of that range. For example, a wavelength at the lower end of the claimed range (i.e., 300 microns corresponding to 1THz) can be more than an order of magnitude different than the wavelengths at which the quantum cascade lasers of Unterrainer operate, and hence can exhibit significantly different penetration depths, e.g., in semiconductor materials.

Moreover, Unterrainer provides experimental data (see Fig. 2 of Unterrainer) indicating that a quantum cascade laser operating at 21 microns with a double metal-semiconductor waveguide requires a *higher* threshold current density – over a wide temperature range – than that required by a quantum cascade laser operating at the same wavelength but having a single-sided surface plasmon waveguide. In other words, at the operating wavelengths with which Unterrainer is concerned, the use of a double metal-semiconductor waveguide is disadvantageous. That is, Unterrainer in fact *teaches away* from the use of such double metal-semiconductor waveguides in QC lasers.

Further, Xu does not cure the shortcomings of Unterrainer in this regard. More particularly, Xu discloses quantum cascade lasers that operate in the terahertz region. It, however, does not teach or even suggest the use of double-side metallic waveguides for confining the lasing modes in such lasers.

Accordingly, claim 1 is patentable over the combined teachings of Unterrainer and Xu.

The Office Action further rejects claims 1, 4, 6, 9-13 and 18 as being obvious over Xu in view of Unterrainer.

The arguments presented above apply with equal force to establish that these claims distinguish patentably over the combined teachings of Xu and Unterrainer. In particular, Xu does not teach utilizing double-sided metallic waveguides for confining the lasing modes in the QC lasers it describes. And, as noted above, Unterrainer is not concerned with the range of operating wavelengths recited in the above claims, and more significantly, it presents data that would dissuade one of ordinary skill in the art from using double-side metallic waveguides in QC lasers.

The Office Action rejects claim 7 as being obvious over Unterrainer in view of Xu and further in view of Published U.S. Patent Application Number 2004/0105471 of Kneissl.

Claim 7 depends indirectly (via claim 5) on independent claim 1, and hence incorporates its features. Claim 7 further recites that at least one of the metallic layers can have a multi-layer structure comprising a layer of gold disposed over a layer of titanium.

As discussed in detail above, the combined teachings of Unterrainer and Xu fail to teach or suggest the following salient feature of claim 1, and consequently that of claim 7: a double-sided metallic waveguide for confining the lasing modes within the active region. Kneissl does not bridge the gap in the teachings of Unterrainer and Xu. More specifically, Kneissl, which is generally directed to nitride laser diode arrays, does not teach or suggest utilizing double-sided metallic waveguides for confining the laser modes of those nitride laser diodes, much less the modes of QC lasers operating in the frequency range of about 1 THz to about 10 THz.

Claim 16 is rejected as being obvious over the teachings of Unterrainer.

Claim 16 depends on claim 15 and further recites forming the active region by molecular beam epitaxy. As claim 16 incorporates the features of claim 15, it is also patentable over Unterrainer.

Rejections Under 35 USC 102

The Office Action rejects claims 15 and 17 as being anticipated by Unterrainer.

Claim 15, as amended, recites a method of confining a mode profile in a quantum cascade laser, which operates in a frequency range of about 1 THz to about 10 THz, by disposing an active region of the laser between an upper metallic layer and a lower metallic layer. Each metallic layer has a thickness larger than a skin depth of radiation in that metallic layer in the laser's operating frequency range of about 1 THz to about 10 THz.

As discussed in detail above, Unterrainer not only fails to teach the use of double-sided metallic waveguides in QC lasers that operate in the range of about 1 THz to about 10 THz, but it, in fact, teaches away from the use of such waveguides in the QC lasers that it discloses. More specifically, Unterrainer presents experimental data showing that the use of such double-sided waveguides, rather than a single-sided surface plasmon waveguide, degrades the laser's performance.

Accordingly, claim 15, and claim 17 that depends on claim 15, distinguish patentably over Unterrainer.

Double Patenting Rejection

The Office action provisionally rejects claims 1, 8-14 and 18 under obviousness-type double patenting as being unpatentable over claims 1, 8, 14, 17, 19-20, and 24 of a copending Patent Application No. 10/661831.

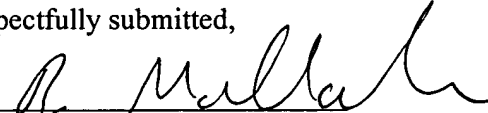
In response, Applicants file the attached Terminal Disclaimer to over this rejection.

CONCLUSION

In view of the above amendments and remarks, Applicants respectfully request reconsideration and allowance of the application. The Examiner is invited to call the undersigned at (617) 439-2514 if there are any remaining issues.

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Respectfully submitted,

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